NRL Researchers Evaluate Electronic Chart System for Navigation

Scientists in the Naval Research Laboratory's (NRL's) Marine Geosciences Division recently tested, demonstrated and evaluated a prototype electronic chart system on Amphibious Assault Vehicles (AAV) to aid navigation around mines and obstacles in the surf and beach zones.

AAV crew workload can be intense. For example, operators have only a small portal through which to navigate a narrow lane (i.e., a safe path from ship to shore that has been cleared of mines and other obstacles). The crew's ability to attend to outside visual cues, such as marker buoys, may be seriously diminished by physical and environmental barriers, such as sea spray, fog, darkness, and other factors. In addition, one crewmember, the crew chief, is responsible for navigation, while another, the driver, steers the vehicle. Communication between these crewmembers is vital for successful navigation, yet considerably hampered by the fact that they are located remotely from one another.

An electronic chart system was expected to improve communications, facilitate shared situational awareness among crewmembers, improve their ability to precisely navigate assault lanes, and ultimately reduce the requisite lane width. Any new navigational system - such as an electronic chart - being considered for these platforms "should be capable of conveying critical navigation information in a manner that is easily interpretable under often stressful conditions," said Ms. Maura Lohrenz, leader of the Moving-map Capabilities (MMC) Team in NRL's Mapping Charting and Geodesy Branch. Such a system should aid a driver in controlling the vehicle by displaying the vehicle's current location and track, along with upcoming waypoints and lane boundaries.

The Office of Naval Research funded the MMC team to equip AAVs (figure 1, at bottom of page) with a prototype electronic chart system and test it for potential improvements in AAV lane navigation. To develop the most reliable and accurate demonstration product possible with the funding available, NRL used commercial off-the shelf Differential Global Positioning System (DGPS) and independent heading sensor, and government off-the-shelf FalconView software, which is the moving-map component of the military's Portable Flight Planning Software.

A case study performed by the Office of the Defense Standardization Program in 1996 identified an Army-developed, 17-pound GPS receiver as costing over $40,000. A smaller, more recent version is the Small Lightweight GPS Receiver (SLGR), weighing around four pounds and with a cost of about $4,000 each. Until recently, both military

and commercial GPS receivers were power hungry, bulky and very expensive, remarked NRL Computer Scientist Stephanie Edwards. "This is no longer the case. Reasonably priced commercial GPS systems can now be found virtually anywhere in the United States."

With the May 2000 discontinuance of Selective Availability, based on a March 1996 Presidential Decision Directive, commercial GPS users now have access to a highly accurate, stable system of satellites, with no limitation or degradation from the government. This ensures reliability that, until recently, was available only for military use. In turn, the Federal Government now can leverage the advancements made by commercial producers. Many of the nation's military platforms, including fighter jets, tanks and AAVs, were not designed to support a GPS system. Therefore, integration of a commercial GPS product on these platforms may actually be more appropriate than a military GPS.

NRL configured several AAVs with a water-resistant display connected to an Argonaut computer temporarily installed in the rear of the vehicle. The computer was a standard 1.3 GHz PC running Windows 2000, which accommodated the AAV space restrictions. The display was a 10.4-inch Nauticomp color monitor, attached to the vehicle driver's hatch to remain out of the way when the vehicle was not in operation. A Furuno DGPS antenna was placed on the outside of the vehicle, slightly aft of the crew chief hatch, and connected to a Furuno GP-36 DGPS receiver using a pre-existing thru-hull cavity. A Furuno PG-1000 heading sensor was included to stabilize the moving-map display while the vehicle was stationary. The heading sensor was positioned in the rear of the vehicle with the PC and receiver. NRL wrote software to integrate the heading sensor data with the DGPS data for input into FalconView. The system components are shown in Figure 2.

The FalconView moving-map software accepts positional input from any National Marine Electronics Association compliant GPS system, Precision Lightweight GPS Receiver (PLGR) data, and Predator data. FalconView can display several different map data types, including Raster Product Format, standard National Geospatial-Intelligence Agency charts, standard National Oceanic and Atmospheric Administration charts, and Geo-referenced Tagged Image File Format (GeoTIFF).

After integrating software and hardware peripherals on a rugged, water-resistant PC, NRL processed appropriate navigation information into GeoTIFF to be displayed as an electronic chart; displayed precise lane coordinates as an overlay on the chart; demonstrated the resulting prototype system during several Navy exercises; and evaluated how AAV drivers responded to the system.

The NRL prototype moving-map system has been tested on AAV platforms several times over the past two years. The system was also tested on the Navy's Landing Craft Utility (LCU) and Landing Craft Air Cushion (LCAC). AAV testing took place at the Amphibious Vehicle Test Branch at Camp Pendleton, California, and at the 3rd Platoon, Company A, 4th Assault Amphibian Battalion Reserve Unit at the Naval Construction Battalion Center in Gulfport, Mississippi. For each demonstration

session, the NRL team spent one day installing the moving-map equipment on the test vehicles and provided a short training session for the crew. The following days were spent testing the system and evaluating crew performance while navigating with the moving-map system versus their baseline means of navigation.

The baseline means of AAV navigation tested was a military PLGR displaying the vehicle position in latitude and longitude on a small hand-held device, providing current location information and navigation guidance by indicating whether to turn left or right - based on a preset course - to reach the next waypoint. Standard procedure called for the crew chief to operate the PLGR while relaying directional information and instructions to the driver. Since these crewmembers were located on opposite sides of the vehicle, all communication was achieved via internal radio link.

Although the PLGR was used as the baseline for these tests, it is not always available to every AAV crew in either training or wartime environments. Additionally, the crewmembers exhibited unfamiliarity with its function that required extra training time. The NRL team also spent about ten minutes explaining the moving-map concept and instructing drivers on its operation. A pre-determined course based on a cleared area was used for each test. Specific waypoints were entered into both the moving-map system and the PLGR. The PLGR showed position numerically, while the moving-map system showed position graphically.

When navigating with the moving-map display, AAV drivers were instructed to follow the lane markings on the display and to stay as close to the centerline as possible. When navigating with the PLGR, AAV drivers were told to aim for the next waypoint as precisely as possible. The moving-map display was turned off during PLGR tests, and the PLGR was not issued to drivers during moving-map tests. Both test conditions (moving-map and PLGR) were repeated with the same drivers on the same course, in both clockwise and counterclockwise directions to reduce familiarity. These runs were repeated over several days; the vehicle's latitude/longitude position was recorded at a rate of 1 Hz during each run.

Results were determined by calculating how well the drivers could stay in their lane with the moving-map versus the PLGR. Individual runs were compared to the actual course and results were measured as cross track error (CTE), which is the positive perpendicular distance between the planned route and the actual track (recorded as a series of latitude and longitude points from the DGPS receiver) and is similar in magnitude to root mean square error.

The drivers who had experience using a PLGR were reluctant to accept that the moving-map display might improve their lane navigation performance. However, even the experienced driver experienced a common PLGR problem: missing a waypoint. "When a waypoint is accidentally missed while using a PLGR, the driver can only aim for the next waypoint," said Ms. Edwards. "There is no way to regain the track until the next waypoint is reached." This creates a potentially dangerous situation as the AAV runs the risk of hitting a mine whenever it is outside the predetermined lane. The longer it remains outside the lane, the more risk it assumes.

The plot in figure 3 reveals significant reductions in CTE (and, thus, a significant reduction in lane width requirements) when driving with the moving-map display versus the PLGR. Such a reduction in lane width equates to a corresponding reduction in labor, time, and threat to safety required to clear the lane prior to an assault. Drivers also were able to complete the course in significantly less time with the moving-map (~11 min) versus PLGR (~14 min), which would further reduce potential risks to the crew during an assault.
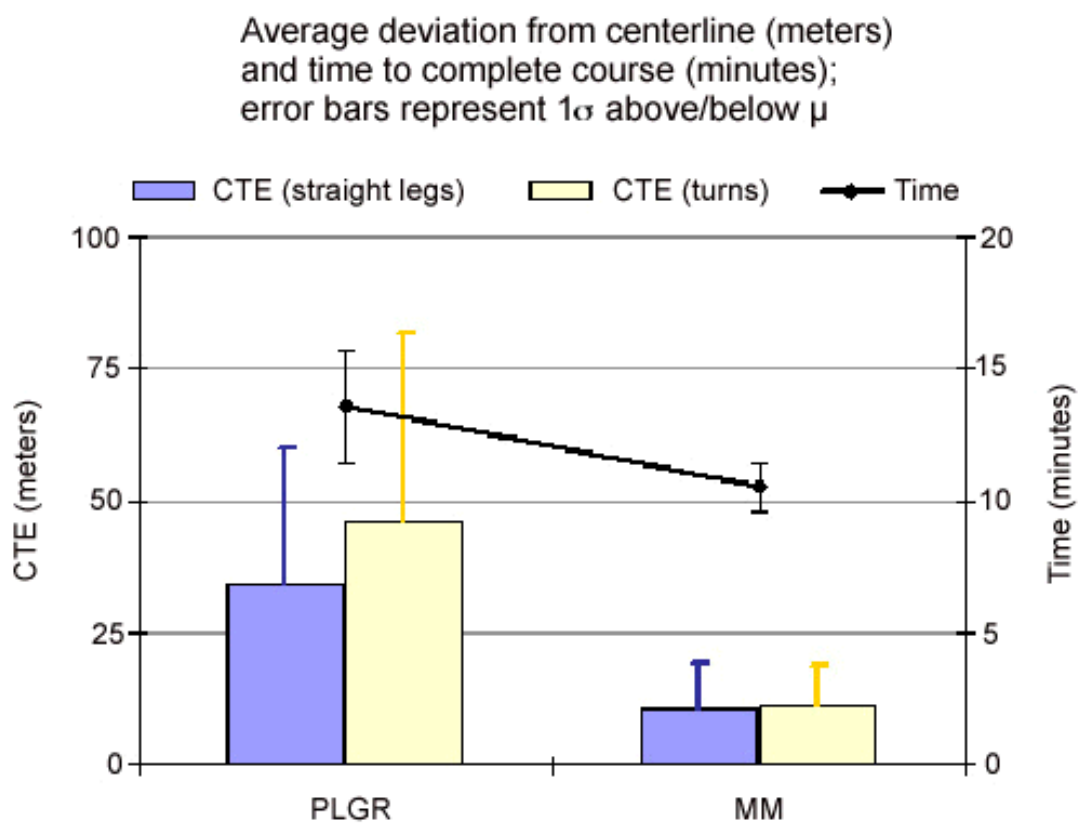
Based on these results, the Mine Warfare Readiness and Effectiveness Measuring (MIREM, 2003) team recently recommended in a fleet-wide Navy message that "some type of graphic navigation system / display should be expedited to the fleet. The system should provide ... clear navigational and situational awareness (craft displayed relative to intended track), direct interface with the craft driver (reduced maneuvering reaction time), and a means to ingest and display EDSS data (minimized error in entry and transfer of information)."

Figure 1

Figure 2

Figure 3

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